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Modeling context-aware distributed knowledge

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Main Goal and Proposition

Research goal :

to model multi-dimensional decision-making processes using artificial agents

Propositions :

- use causal cognitive maps to model software agents
- compose a collective solution to a goal through a distributed and incremental process, based on interactions
- use context in cognitive maps to define agent's mental states

Philosophy and artificial intelligence

Theoretical foundations: AI as a laboratory

Philosophy and Artificial Intelligence: both try to understand all different kinds of perception, action and intelligence

The association of this domains allows :

- to simulate reasoning in software programs, starting from a given conception of what can be the mind;
- to do controlled experiments aiming to understand the knowledge representation systems used in our mind to represent the world;

AI as a laboratory :

- a specified idea of what is the mind leads to experiments about new software architectures
- experiments can be seen as a way of really *doing* philosophy, because they search the conditions that make possible cognition in general - human intelligence

Philosophy and artificial intelligence

Theoretical foundations: AI as a laboratory

Intelligence:

the capacity of problem solving and decision

There is no problem solving and decision capacity without some representation of the world

Folk Psychological Constructs help us to model the knowledge representation systems used by our mind, using mental states

Advantages of Folk Psychology : operational, comprehensible, an instrument to predict and explain behavior, to manipulate mental states

Philosophy and artificial intelligence

Theoretical foundations: Functionalism

This use of mental states can act as a functionalist theory if we identify mental states in terms of their causal-functional relationships

Functionalism identifies mental content with causal-functional roles [Goldman,93]

Causal Covariance Theory of Content [Allen,02]

proposes that mental states get their content by being causally related only to what they are about (e.g., to those mental states belonging to its own specific context)

This idea of using context to define mental states is adopted to manipulate mental states in a Multi-Agent System, through the use of Cognitive Maps

Cognitive Mapping

Theoretical foundations:
using cognitive maps to model individual and collective beliefs

Cognitive Map : graphical representation of individual or collective beliefs, regarding a specific domain

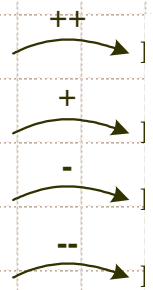
Cognitive mapping is used by psychologists and decision makers to :

- understand the behavior of actors participating in a decision making process
- detect conflicts (incoherent viewpoints)
- discuss points of view

State of the wold

Task

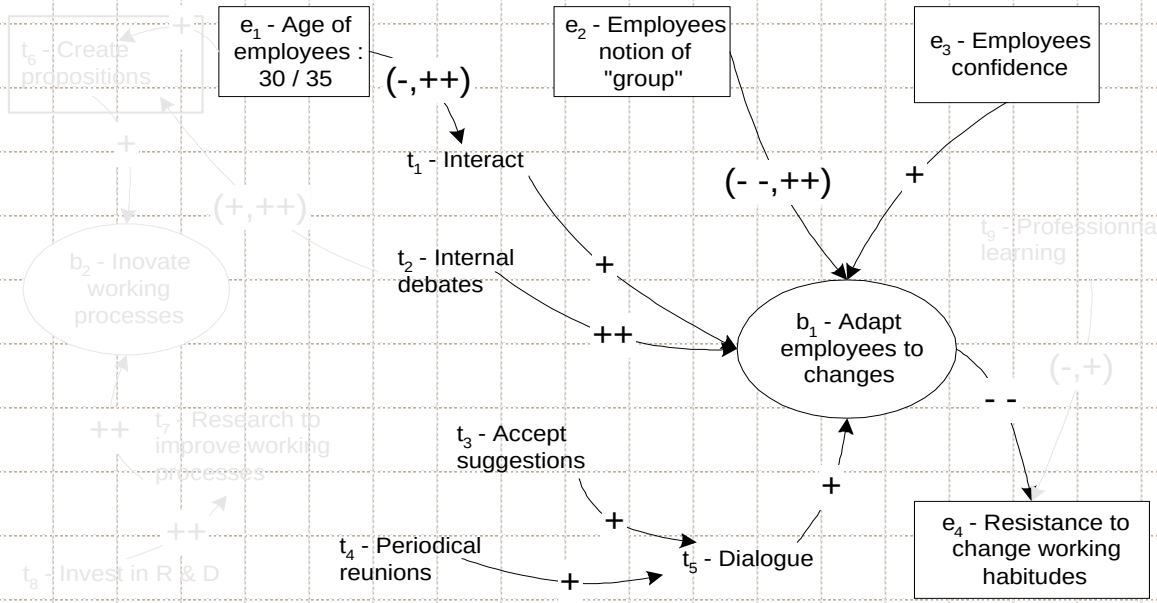
Goal



[Carlson et Walden,96]

Cognitive Mapping

Theoretical foundations:
using cognitive maps to model individual and collective beliefs



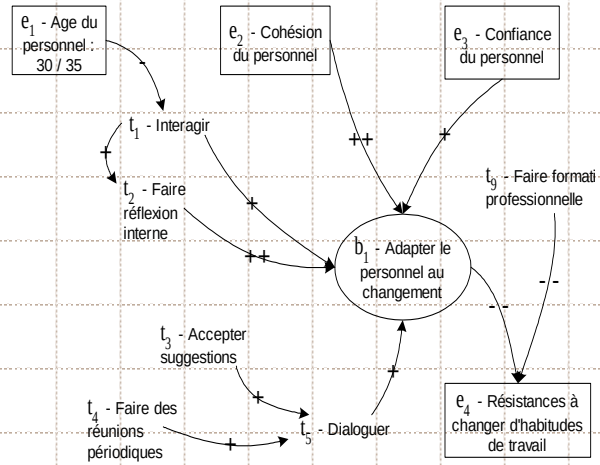
Example of a partial cognitive map [Louçã,00]

Reflexive character of CM - we each construct our private *versions of reality* and deal only with those constructions, which may or may not correspond to some real world [Lissack & Ross,99]

Cognitive Mapping

Theoretical foundations:
using cognitive maps to model individual and collective beliefs

Collective interpretation using CM - according to Karl Weick and others, organizations can also be seen, at another abstraction level, as systems of construction and interpretation of reality
[Weick,95] [Lissack & Gunz,99]



Different levels of construction and interpretation of reality:

- individual
- collective

CM facilitate reasoning, communication and discussion about individual and corporate knowledge

Research in AI using Cognitive Maps

Theoretical foundations: state of the art

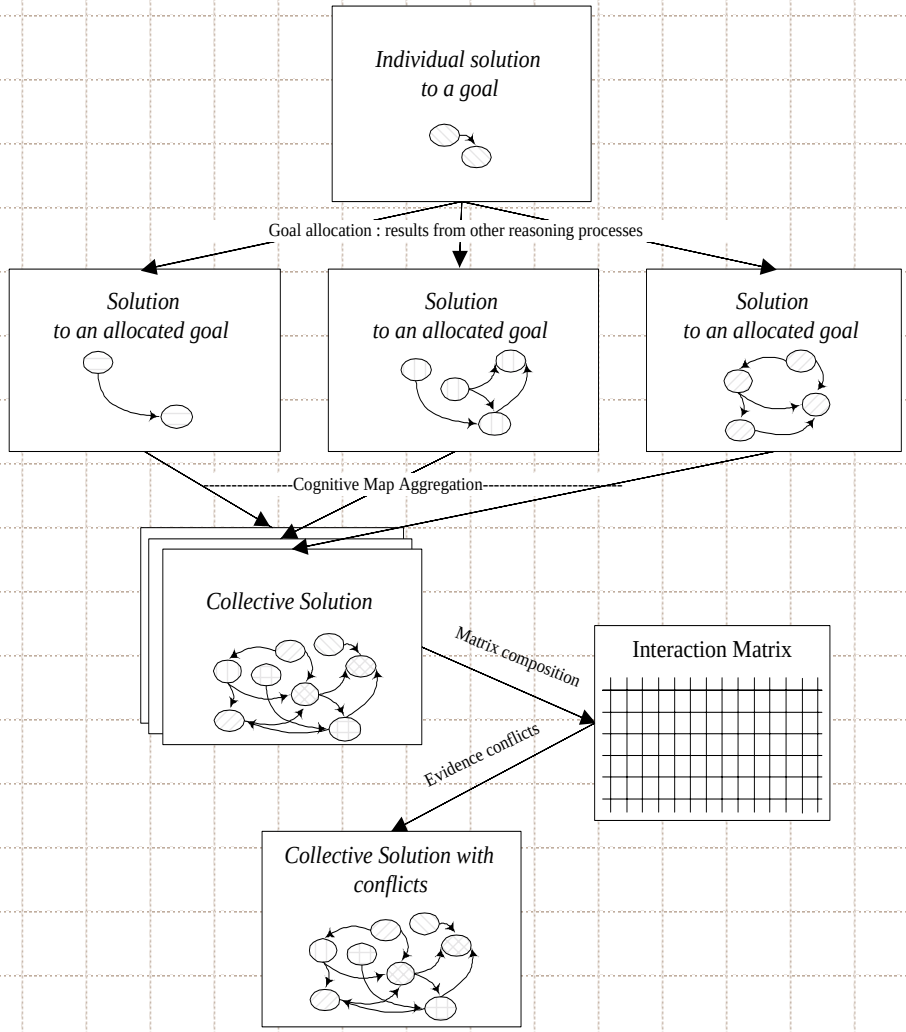
	[Marchant, 99]	[Wellman, 94a]	[Console et al.,89]	[Zhang et al., 92 et 94]	[Park & Kim, 95]	[Chaib-draa, 97a, 97b et 98]
IA domain	Inference from fuzzy implication	Causal inference in qualitative probabilistic networks	Inference in causal networks	Causal inference ; MAS ; neural networks	Causal inference with circuits	Causal inference ; MAS
Formal model	Cognitive map as a logical system	Cognitive Map	Causal link as an implication formula	*NPN Logic*	*Logique* et *Relations NPN Logic and Relations with circuits*	Cognitive Map
Kind of links between concepts	Fuzzy implication	Probabilistic causality	Causality	Causality	Causality	Causality
Reasoning from Cognitive Maps	yes	yes	Reason from causal networks	yes	yes	yes
Detect and solve conflicts in MAS	no	no	no	yes	no	yes

Modeling context-aware distributed knowledge

Proposition: distributed and incremental reasoning process

An agent uses the set of concepts represented in its cognitive map. The agent composes its individual solution to the goal, represented by a partial cognitive map.

Each agent that receives an allocation message including a sub-goal, starts its own reasoning process and, in return, responds with a solution to the sub-goal. This distributed reasoning process allows representing several points of view concerning the sub-goals.

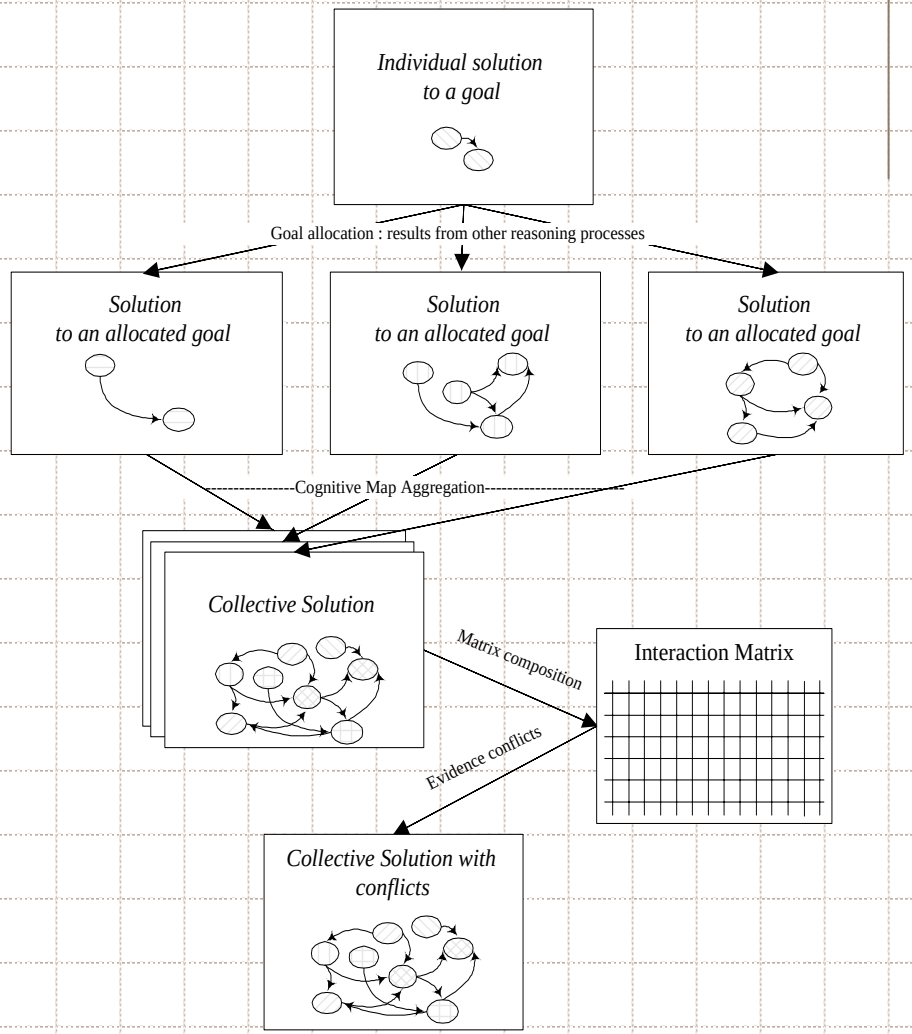


Modeling context-aware distributed knowledge

Proposition: an incremental, distributed and incremental reasoning process

The composition of the *interaction matrix* is done through the *NPN^e Methodology of Aggregating Cognitive Maps* [Louçã,02a].

Only the most acute opinions are considered to compose the collective solution. A link such as (+,--) evidences a conflict in the organization. This way, the collective reasoning mechanism will detect and evidence conflicts in the collective solution, graphically represented in the form of a cognitive map, allowing a clear discussion and negotiation between the actors.



Modeling context-aware distributed knowledge

Propositions: cognitive maps standing for mental states

Cognitive maps composed on one hand by concepts and by causal links between those concepts, in a *strictu senso* way [Weik,79] and on the other hand to consider the context of concepts, allowing some kind of inference

This way, we can define mental states from cognitive maps by getting their content from the concepts being causally related to their context. More precisely, a mental state is represented by a concept and its context.

In cognitive mapping terms we have :

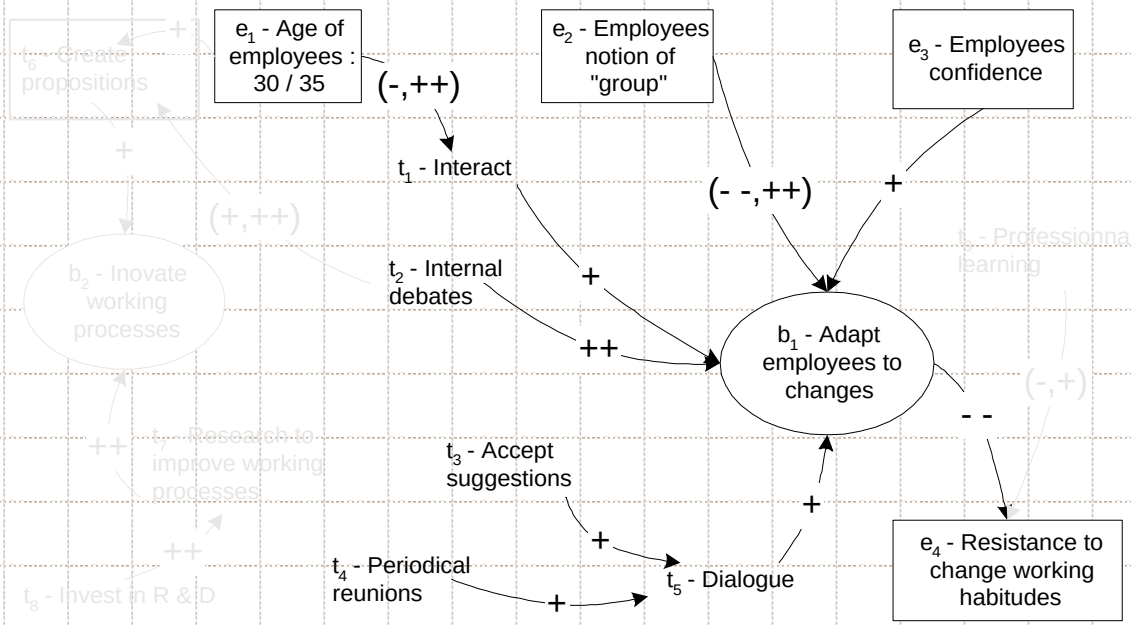
(1) concepts can't be understood without context,

(2) the context of a concept is composed by concepts that influence and that are influenced by the main concept and by links between those concepts,

(3) each concept is coupled to its context, which can be called a *scheme* [Bougon & Komocar,94]

Modeling context-aware distributed knowledge

Propositions: cognitive maps standing for mental states



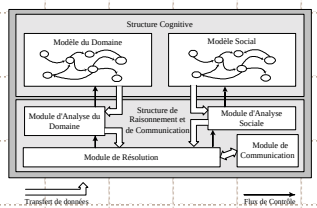
Scheme – a concept and its context [Louçã,02]

Modeling context-aware distributed knowledge

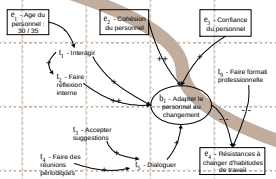
Propositions: cognitive maps standing for mental states

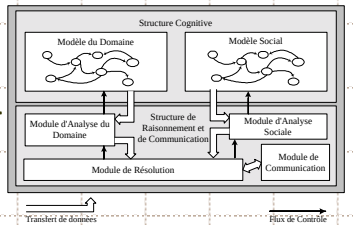
to interact agents communicate schemes

communicating schemes influence agent's mental states and develops collective knowledge

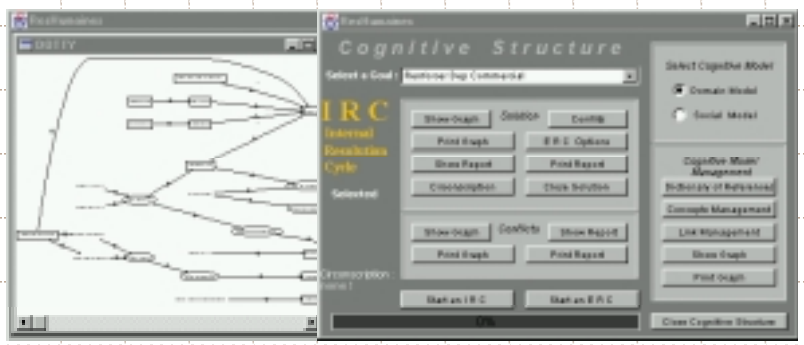


Scheme

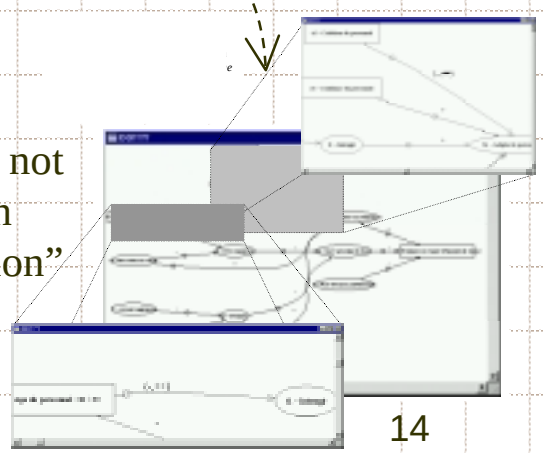




If concepts are similar and if there are conflicts, then the graphical interface supports discussion (and argumentation) between individuals, to converge to a common scheme



If concepts are not similar, then "CM aggregation"



Application

Prototype and application in an industrial entreprise

These propositions above were tested in StrAgent, a distributed software system to support decision-making in human organizations

SETCOM – *Electronica, S.A.* (Palmela)

industrial enterprise in the domain of telecommunications and electronics

Cognitive Maps were built from documents and interviews
5 teams - *organisation, products, markets, human resources* and *information departments*

Main goal : to model ***collective discussion*** and ***consensual decision***

- to represent actors knowledge
- to show conflicts
- to support conflict resolution

Conclusion

A model of multi-dimensional reasoning in a multi-agent system is proposed.

Cognitive maps are used as instruments to represent agent's mental states.

Schemes are used to compose a collective solution to a goal through a distributed and incremental process, based on agent's interactions.

The emergence of collective knowledge is represented in the cognitive map of each agent.